H Block

Review of H-Block Test Results with PCS Handsets

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On behalf of Verizon Wireless
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Introduction

- V-COMM
  - Wireless engineering firm with significant expertise in all CMRS CMRS wireless technologies
    - Clients include major wireless carriers and smaller carriers
  - Practical experience in RF design, engineering, testing and system optimization for all wireless technologies
  - Contracted by Verizon Wireless to study the impact of H-Block Block on incumbent PCS –
    - Conducted preliminary handset testing
    - Assisted in development of CTIA H-Block test plans
    - Coordinated testing issues with test labs & carriers
    - Conducted detailed analyses of the CTIA test results, and results results of Motorola's tests (filed Aug 24th)
    - Provided technical assessment of H-Block power limits and OOBE OOBE limits necessary to protect incumbent PCS, based on test test results

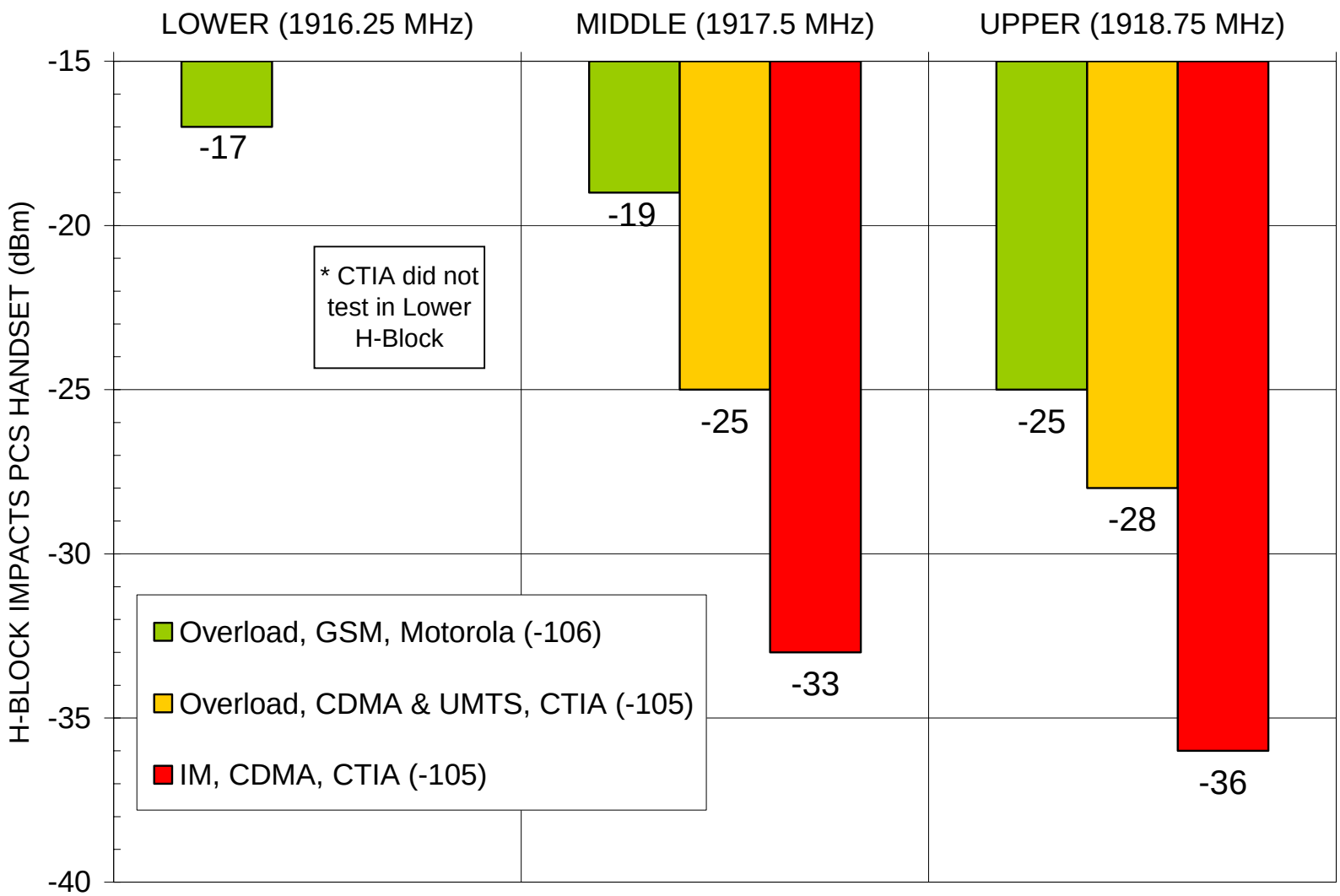
Review of CTIA H-Block Tests

- Performed by two independent test labs (PCTEST & & Winlab)
- Variety of PCS handsets (4 GSM, 6 CDMA, and 1 UMTS handset)
- Real-world test conditions
  - Typical operating & noise levels for indoor environments, which is where H-Block is likely to occur
  - Represent signal fading conditions
    - Tested CDMA & UMTS handsets to the operating levels of -105 dBm to capture impact during fades
    - Tested GSM handsets to -102 dBm (ref. to GSM sensitivity)
- Tested at room temperature and 100 degrees F
- Included tests for Receiver Overload, IM, AWGN (in-band noise), and OOBE

Review of Motorola H-Block Test (Aug 24 filing)

- Tested 1 GSM handset and 1 CDMA handset in receiver overload tests
- Measured performance degradation for 1 and 3 dB desense thresholds, using standard error rates
  - GSM handset measured sensitivity at -109 dBm
- Used operating levels of -106 and -108 dBm for GSM GSM handsets
  - These levels more closely represent faded signal conditions
  - Vs. CTIA's tests used -102 dBm for GSM (ref. sensitivity), and and -105 dBm for CDMA & UMTS
  - Analysis of equivalent operating level and protection for both, both, use -106 dBm for GSM (Motorola data) and -105 dBm dBm for CDMA (CTIA data)
- Tested with no environmental noise added, and at room room temperature

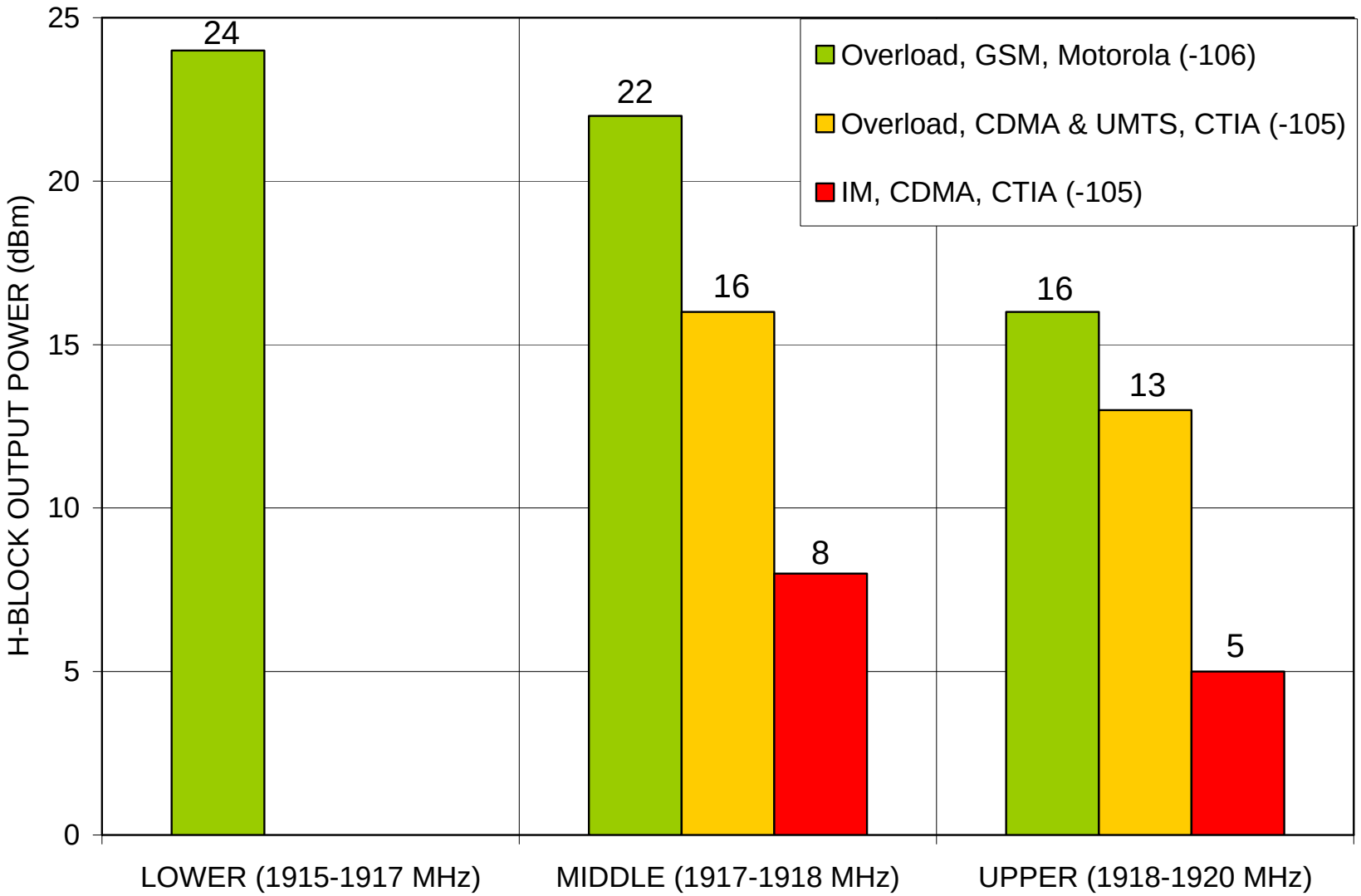
Test Results of H-Block Impacting PCS Handsets



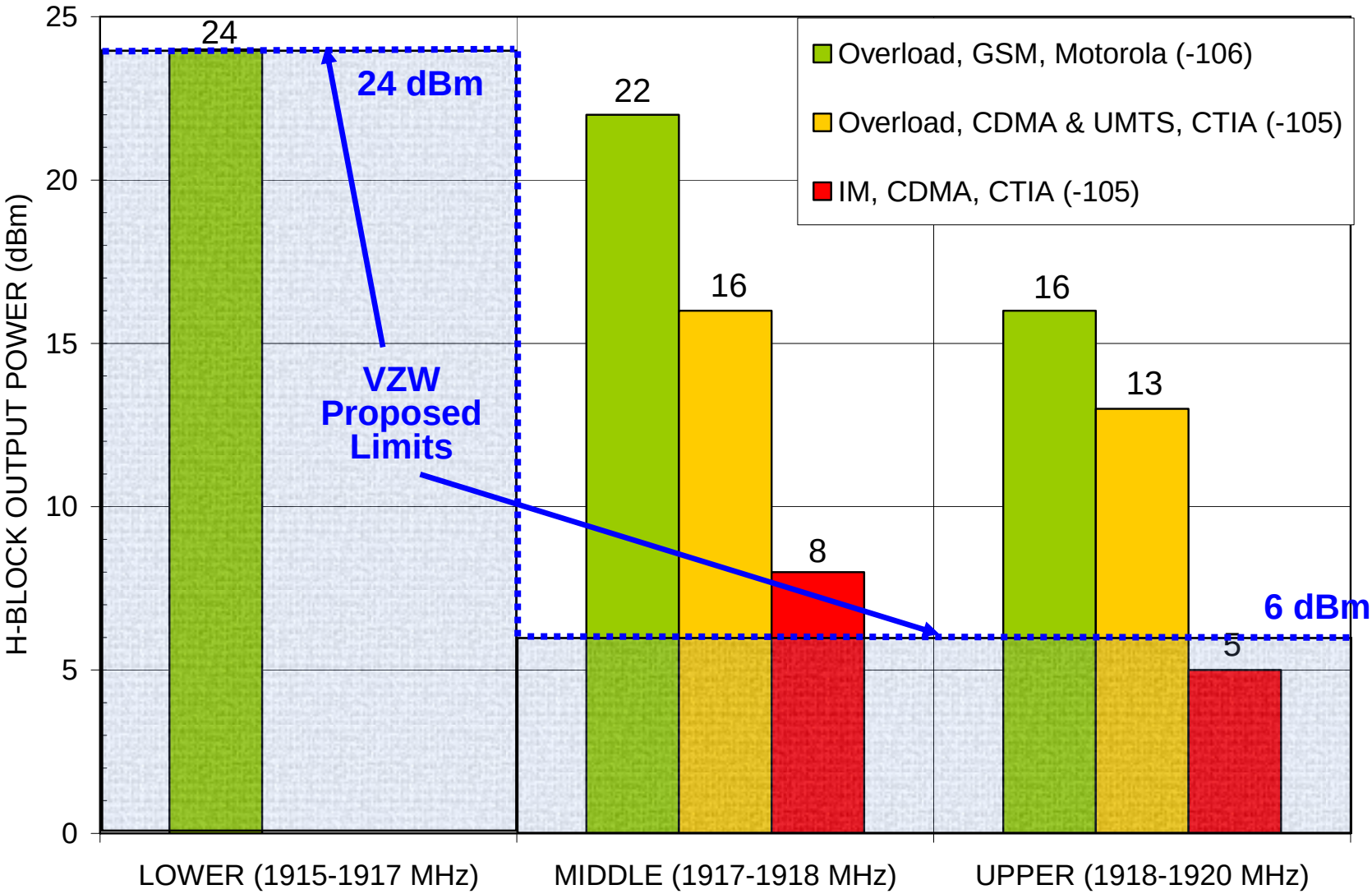
Results of H-Block Tests

- IM interference occurs at -36 dBm – for half the CDMA handsets in CTIA tests
- Overload interference occurs at -28 dBm – for CDMA and UMTS handsets in CTIA tests
  - UMTS handset tested was very sensitive to temperature; overload interference at -36 dBm in CTIA tests at 100°F (Higher temperature caused receive filter to drift providing less rejection at H-Block)
- Overload interference occurs at -25 dBm – for GSM handsets in Motorola test (at -106 dBm operating level)
- Middle of H-Block is about 3 dB less sensitive than upper H-Block, per results of CTIA tests
- Lower portion of H-Block is the least sensitive, allows higher power in the 1915-1917 MHz region

H-Block Power Limits Needed To Prevent Interference



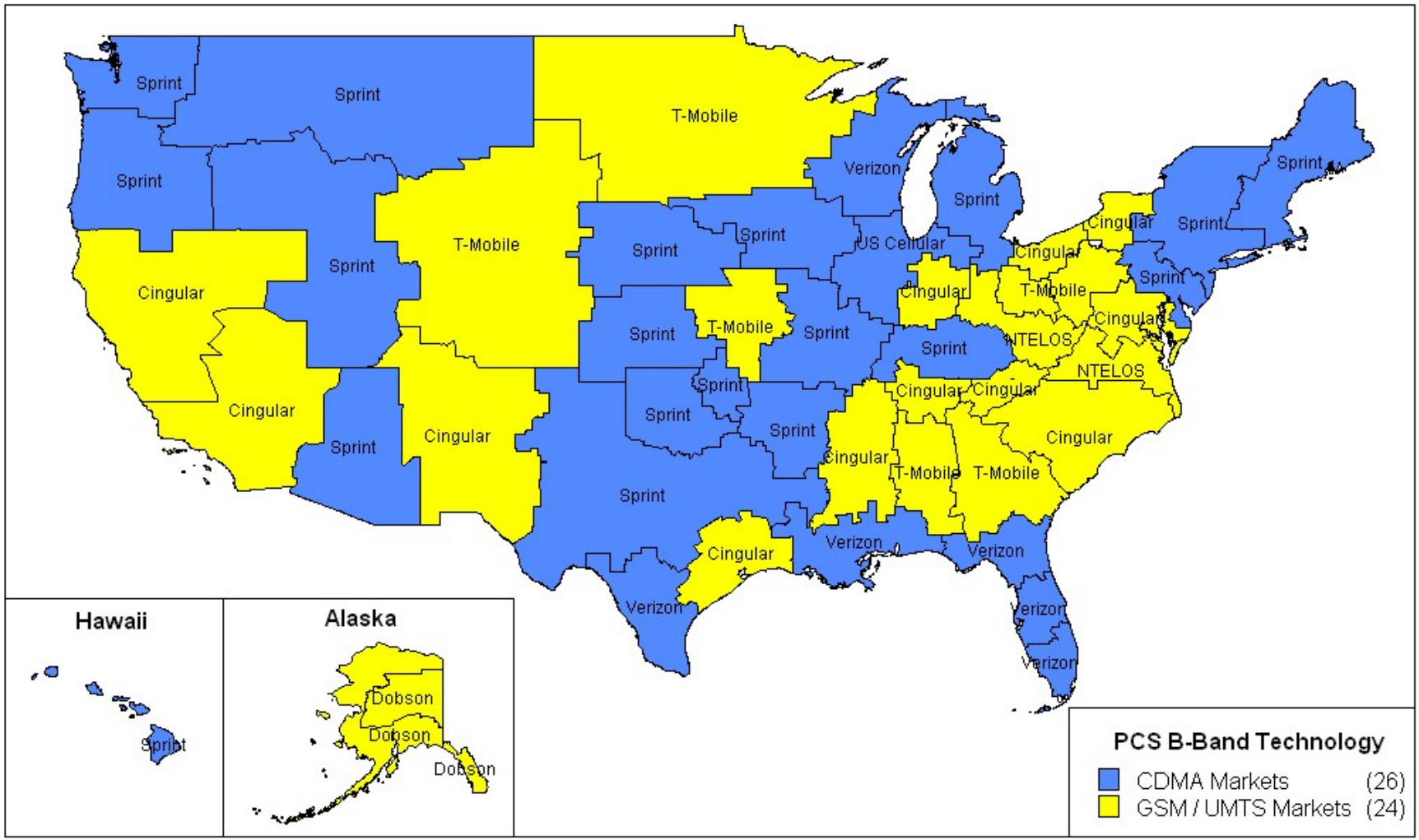
VZW Proposed Power Limits for H-Block



H-Block Power Limits Needed to Prevent Interference

- To protect all PCS handsets against Overload and IM interference, 5, 8, and 24 dBm power limits are needed for upper, middle and lower portions of the H-Block (based on test results)
  - 5 and 8 dBm limits needed for CDMA IM protection
  - 24 dBm limit needed in lower H-block for GSM Overload protection
    - Also, 24 dBm in lower H-block is consistent with our independent tests with CDMA handsets for IM protection
  - VZW proposes two band segments for power limits with 24 dBm in 1915-1917 MHz, and 6 dBm in 1917-1920 MHz
- Most sensitive region is upper H-block due to IM interference with CDMA handsets
- IM impacts CDMA mobiles operating on the center 5 MHz of 15 MHz PCS B-Band
  - IM does not occur to GSM due to TDD/half-duplex operation (handsets use switches instead of duplexers)
  - UMTS did not show significant IM interference, however only 1 handset was tested -- not a significant sample – IM interference may occur to other UMTS handsets, UMTS handsets use duplexers
- Separation distance of 1 meter (38 dB path loss) and 3 dB of total additional losses are used in the analysis

PCS B-Band Markets Impacted by H-Block IM

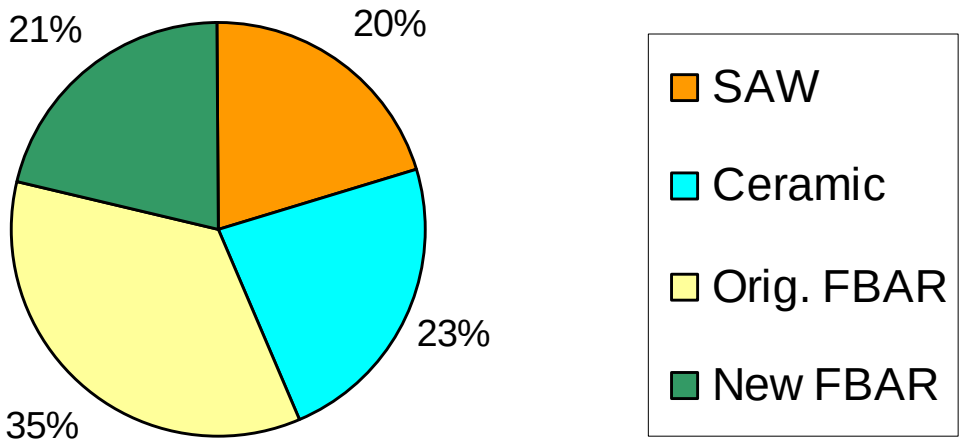


PCS Handset Types

- *Direct Conversion vs. Super-heterodyne*
  - Direct Conversion or Zero IF (ZIF) handset designs are more sensitive to H-Block interference, and is the ‘standard’ design for current and future handsets
    - Qualcomm’s & TI’s chipsets used in CDMA phones are direct conversion designs for over 1 year now
    - All current and future chipsets use this design
  - Super-heterodyne handsets exist within the embedded base, however the Super-heterodyne design is becoming obsolete
  - Existing base of handsets contain both types, and both should be protected from interference
- *Handset Filter Types*
  - Majority of PCS handsets use SAW, Ceramic, and original FBAR filters types, which are sensitive to H-Block interference
  - New FBAR filters provide additional rejection of the H-Block, however they represent a smaller percentage of handsets. Also, they have more temperature variation, which reduces effectiveness at higher temperatures due to filter drift
  - Majority of PCS handsets use filters with insufficient rejection of H-Block, and need protected from interference

Verizon Wireless' CDMA Handsets

- Today's handset designs are direct conversion (ZIF) – have sensitivity to H-Block interference
- Majority of handset filters not effective in rejecting H-Block
  - Includes SAW, ceramic & original FBAR (HPMD-7904) filters
  - Represents 78% of VZW's handsets (VZW selling today) – or about 16 M handsets and growing (filters continue to be sold)



- New FBAR filter (Aglient ACMD7401) provides improved rejection – however, it provides less rejection at higher temperatures, and will take years to significantly penetrate market

Out-of-Band Emissions (OOBE)

- An OOBE limit of -76 dBm/MHz RMS is needed to protect existing PCS handsets from H-Block OOBE interference
- CTIA's H-Block tests demonstrate interference due to OOBE
  - The -76 dBm/MHz limit is supported in CTIA AWGN in-band noise tests showing interference occurs at -117 dBm to PCS handsets
  - Observed for half of CDMA handsets tested
  - Uses 38 dB path loss for 1 meter separation and 3 dB of total additional losses in analysis
- The -76 dBm/MHz OOBE is consistent with CDMA industry standards, and CTIA's test results for many PCS handsets
  - All CDMA & UMTS handsets comply with this limit – CTIA tests showed they are about 20 dB lower than the -76 dBm/MHz standard
  - Half of the GSM handsets tested met this limit – however, one GSM handset measured as high as -71 dBm/MHz in CTIA tests
    - GSM handsets generally do not use transmit filters and as a result they have higher OOBE than CDMA & UMTS handsets

Out-of-Band Emissions (OOBE)

- Agilent confirms H-Block devices can meet this OOBE limit with today's filtering technology
- RMS measurement proposed provides about 9 dB relief for GSM handsets using only 1 of 8 timeslots (Peak will be 9 dB higher)
  - Equivalent to -67 dBm/MHz Peak OOBE for GSM (-76 + 9 = -67)
  - Motorola states that H-block handsets can meet -68 dBm/MHz limit with current designs (for output power of 23 dBm)
  - Thus, some GSM handsets may not require transmit filters to meet OOBE limit when operating at lower power levels
- OOBE interference cannot be filtered at the victim handset because its received as in-band noise, and must be mitigated at the source
- Therefore, the proposed limit of -76 dBm/MHz RMS is reasonable and will protect existing PCS handsets from H-Block OOBE interference

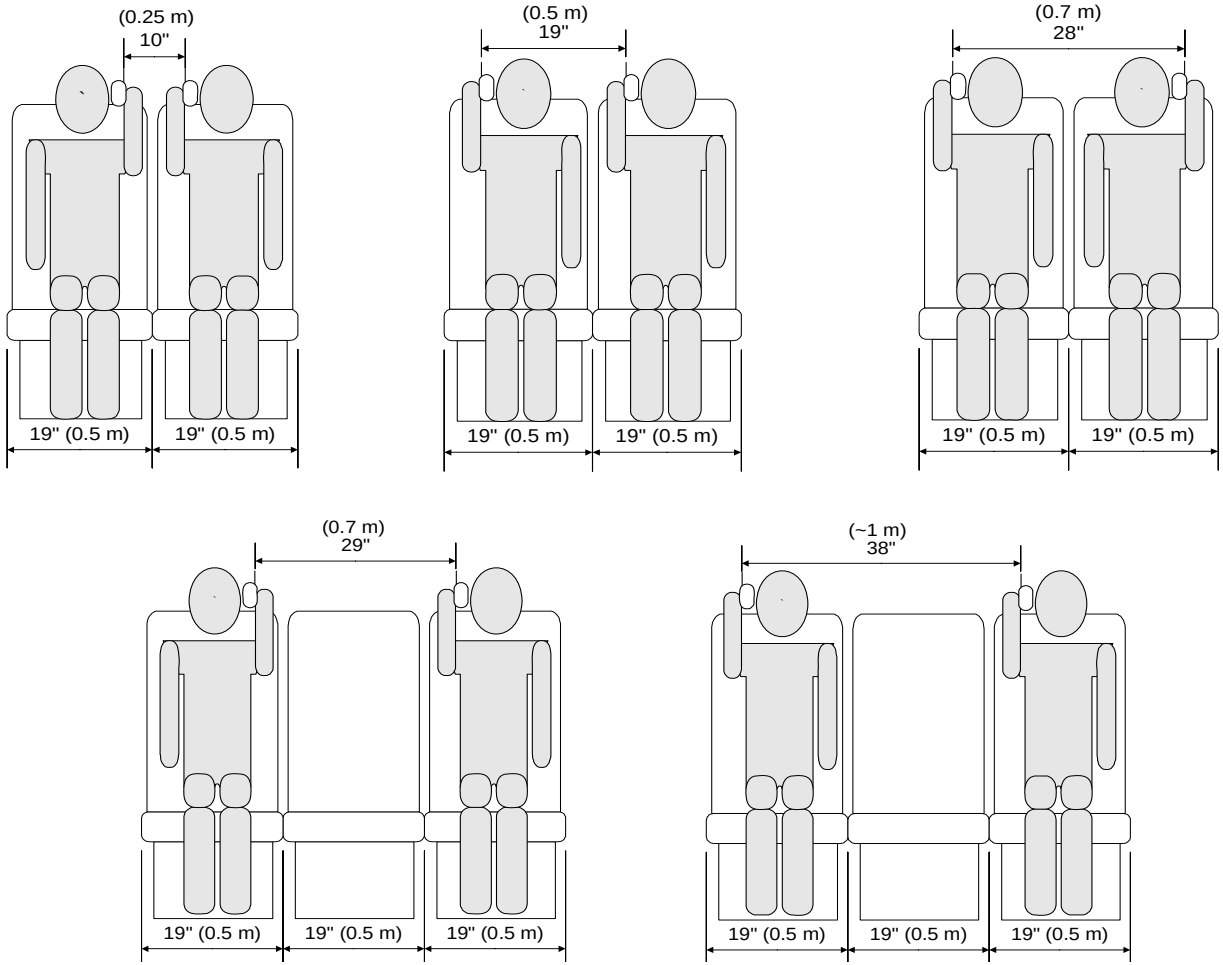
Potential for H-Block Interference

- Inherent problems with probability analyses – they fail to look at the worse or typical cases. Instead, they average all the possible cases over the entire area of a cell site, using unrealistic user densities, making any problems disappear in the “averaging”. They do not focus on where the problems are *likely* to occur.
- In-building and in-vehicle (i.e. trains, buses and airplanes) use are where interference is likely to occur – due to significant attenuation of signal, and closer user separation distances
  - Attenuation of signal reduced by 10 to 20 dB, or more
  - Strong signals outdoors in the range of -80 to -85 dBm are reduced to -100 dBm and lower (often fading to -105 dBm)
  - Handsets transmit at maximum power in these same areas
  - Many customers use handsets in close proximity
  - Occurs often –> substantial part of service for customers
  - Handsets need protection from interference in these areas

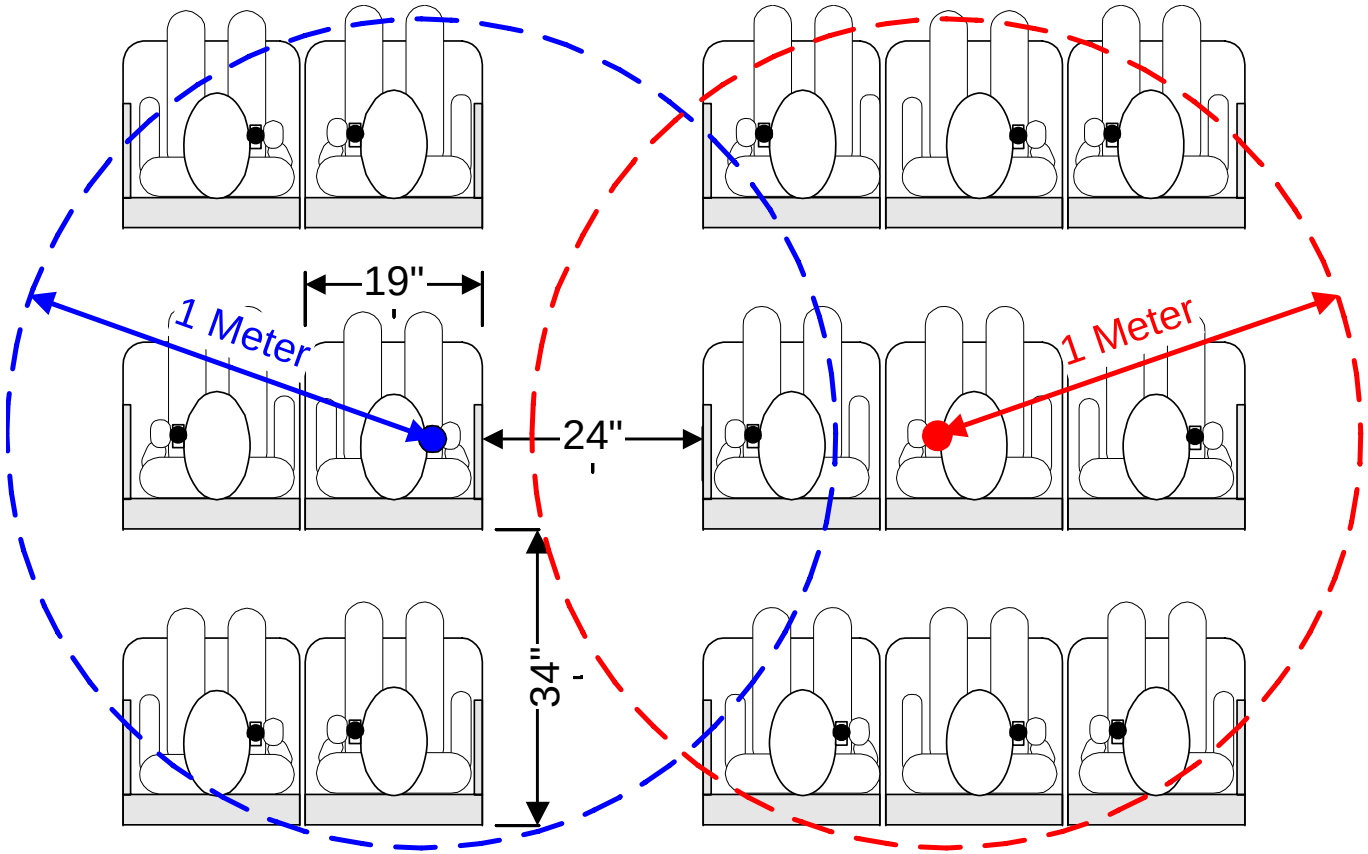
Potential for H-Block Interference

- The “1 meter separation” distance appropriately addresses the *likely probability* of two or more handsets being used in close proximity
- Typical separation distances between PCS phone users in close proximity is 0.25 to 1 meters
- One meter separation distance can include many PCS users (see diagram, up to 9 simultaneous users) – interference is additive with multiple H-Block users in close proximity
- One meter separation distance occurs often enough to merit interference protection – No further probability analysis needed
- H-Block interference impacts all PCS Bands
  - Overload & OOBE interference impacts all PCS bands
  - H-Block IM interference only impacts PCS handsets operating on center 5 MHz of 15 MHz PCS B-Band

Typical Separation Distances between Phone Users



One Meter Separation Distance -- Includes Multiple PCS Phone Users (up to 9 simultaneous users)



Summary

- H-Block power limits are needed to protect PCS handsets from Overload and IM interference
  - CTIA's tests show a power limit of about 6 dBm is needed in upper region 1917-1920 MHz – to protect CDMA handsets from IM
  - Motorola's tests show a power limit of 24 dBm is needed in lower region 1915-1917 MHz – to protect GSM handsets from Overload
  - Majority of PCS handsets sensitive to H-Block interference
  - Future handsets may have improved filtering that are more resilient to H-Block, but will require significant time to penetrate market base of subscribers – new handsets will need testing to confirm future impact
- H-Block OOBE limits are needed to protect PCS handsets
  - CTIA's tests show an OOBE limit of -76 dBm/MHz RMS is needed to protect PCS handsets from H-Block OOBE interference
  - The -76 dBm/MHz limit is consistent with CDMA standards, and is achievable with today's technology
  - OOBE cannot be filtered out at the victim, must be mitigated at the source
- Potential for H-Block Interference depends on user proximity and is likely to occur indoors or in-vehicles, where users densities are the highest, handsets are likely operating at their lowest receive levels and transmitting at highest levels